

NOAA Data Report ERL GLERL-11



STRAITS OF MACKINAC CHEMICAL AND PHYSICAL
CHARACTERISTICS DATA FOR 1973

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Ann Arbor, Michigan
January 1980

Data available on microfiche
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STRAITS OF MACKINAC CHEMICAL AND PHYSICAL CHARACTERISTICS DATA FOR 1973*

Gerald L. Bell

Water samples at standard depths, bottom sediment, and meteorological data were collected in the Straits of Mackinac and Northern Lake Huron at established stations in the course of 94 lake cruises during the 1973 open-water season. The sampling program and analytical methods are described. Chemical characteristics of the water and bottom sediment are listed by cruise for each station and sampling depth. Wind, wave, and sediment data are listed by cruise for each station. The statistical summaries showing lake-wide means, standard deviations, and sample sizes of selected variables are presented by depth for each cruise period.

1. INTRODUCTION

This basic data report presents data collected aboard the Research Vessel *Shenelon* between 22 May and 17 November 1973 in the Straits of Mackinac and the adjacent portions of Lakes Huron and Michigan by the Water Characteristics Branch of the Lake Survey Center, U.S. Department of Commerce, NOAA, National Ocean Survey.

As part of the United States and Canadian Great Lakes Water Quality Agreement, the net exchange of water and its contained dissolved constituents and suspended material between Lakes Michigan and Huron and the factors responsible for the exchange were systematically investigated during the open-water season to determine the impact of Lake Michigan on the water quality of Lake Huron. This investigation provided data to the International Joint Commission relating to the study of pollution problems in the boundary waters (Lake Survey Center, 1973).

Interpretations of the data are not within the scope of this report and will be presented in subsequent publications. Meteorological conditions, profiles of water temperature and transparency recorded at each station, and current data recorded at two towers and two buoys are not included in this report. Reports based on these data were prepared by Pinsak and Chambers (1975) and by Saylor and Sloss (1976).

2. METHODS

2.1 Sampling Program

Water characteristics, bottom sediment, and meteorological data were collected at 50 established stations (Figure 1, Table 1) in the Straits of Mackinac area and at 24 stations in the De Tour-Meldrum Bay area. There were 94 cruises (Table 2), four of which (66, 67, 72, 83, and 84) were devoted to current studies with drogues. Nineteen of the

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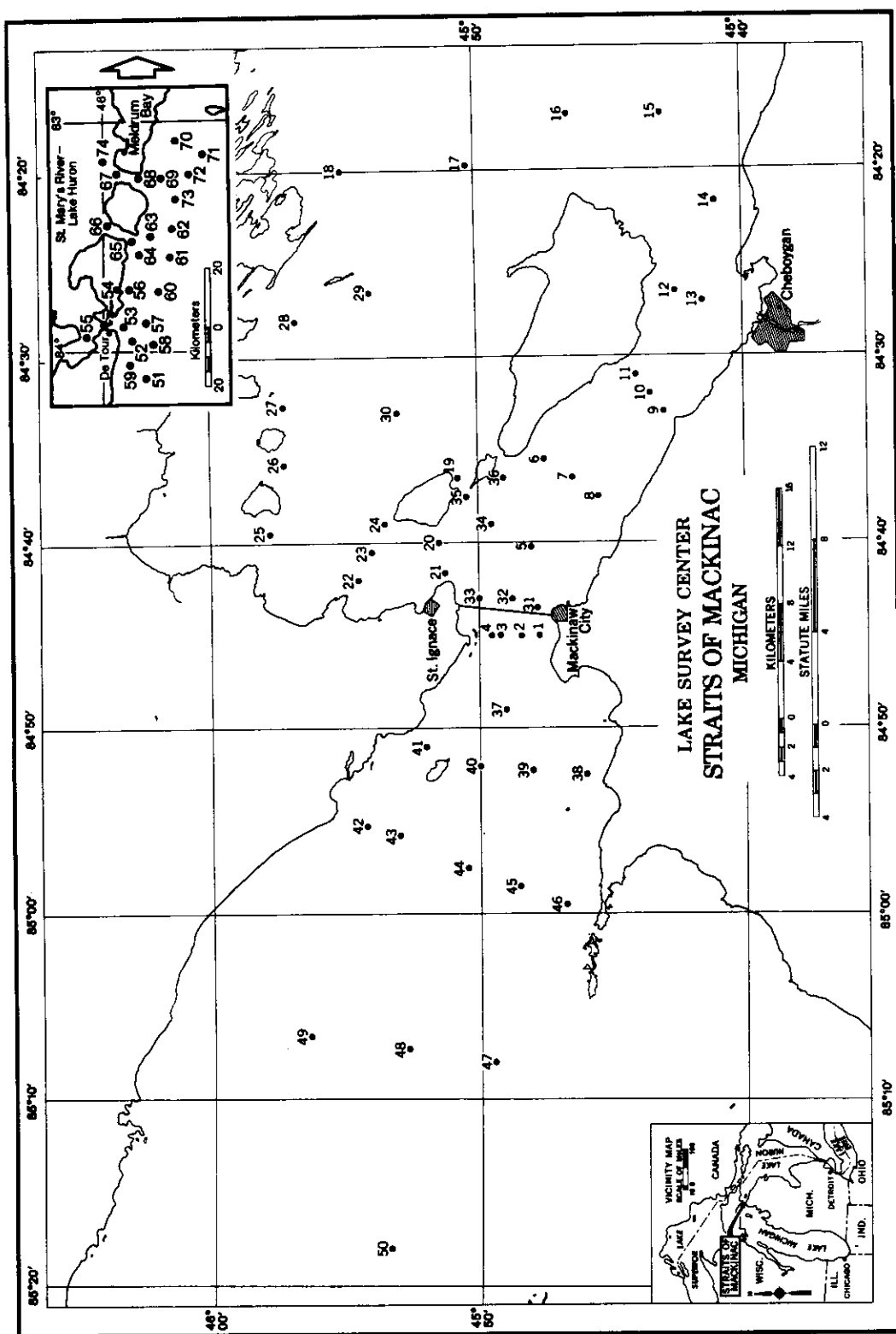


Figure 1. Station locations in the Straits of Mackinac and in the St. Marys River-Lake Huron area during 1973.

Table 1. Station Locations in the Straits of Mackinac and in the St. Marys River-Lake Huron Area During 1973 (by Latitude and Longitude)

Station	Latitude	Longitude	Station	Latitude	Longitude
1	45.79°N	84.75°W	26	45.96°N	84.60°W
2	45.81°N	84.75°W	27	45.95°N	84.54°W
3	45.82°N	84.75°W	28	45.95°N	84.47°W
4	45.83°N	84.75°W	29	45.90°N	84.44°W
5	45.80°N	84.67°W	30	45.88°N	84.55°W
6	45.79°N	84.59°W	31	45.80°N	84.72°W
7	45.78°N	84.61°W	32	45.81°N	84.72°W
8	45.76°N	84.62°W	33	45.83°N	84.72°W
9	45.72°N	84.55°W	34	45.82°N	84.65°W
10	45.73°N	84.53°W	35	45.84°N	84.62°W
11	45.73°N	84.52°W	36	45.82°N	84.61°W
12	45.71°N	84.44°W	37	45.82°N	84.82°W
13	45.69°N	84.45°W	38	45.77°N	84.88°W
14	45.68°N	84.36°W	39	45.80°N	84.87°W
15	45.72°N	84.28°W	40	45.83°N	84.87°W
16	45.78°N	84.28°W	41	45.87°N	84.85°W
17	45.84°N	84.33°W	42	45.90°N	84.92°W
18	45.92°N	84.33°W	43	45.88°N	84.93°W
19	45.84°N	84.61°W	44	45.84°N	84.96°W
20	45.86°N	84.67°W	45	45.81°N	84.98°W
21	45.86°N	84.70°W	46	45.78°N	84.99°W
22	45.91°N	84.70°W	47	45.82°N	85.13°W
23	45.90°N	84.68°W	48	45.88°N	85.12°W
24	45.89°N	84.65°W	49	45.94°N	85.11°W
25	45.96°N	84.66°W	50	45.89°N	85.30°W

St. Marys River-Lake Huron

51	45.87°N	84.12°W	63	45.86°N	83.50°W
52	45.91°N	83.96°W	64	45.89°N	83.58°W
53	45.94°N	83.89°W	65	45.91°N	83.52°W
54	46.00°N	83.89°W	66	45.99°N	83.45°W
55	46.05°N	83.94°W	67	45.96°N	83.23°W
56	45.92°N	83.83°W	68	45.89°N	83.25°W
57	45.87°N	83.88°W	69	45.82°N	83.25°W
58	45.85°N	83.97°W	70	45.78°N	83.09°W
59	45.92°N	84.06°W	71	45.70°N	83.15°W
60	45.83°N	83.74°W	72	45.74°N	83.23°W
61	45.79°N	83.60°W	73	45.78°N	83.34°W
62	45.79°N	83.47°W	74	46.00°N	83.17°W

Table 2. Cruise Schedule

Cruise	Date	Cruise	Date	Cruise	Date
1	22 May	32	24 July	63	11 Oct.
2	23 May	33	25 July	64	12 Oct.
3	24 May	34	26 July	65	13 Oct.
4	25 May	35	27 July	66	15 Oct.
5	29 May	36	28 July	67	17 Oct.
6	30 May	37	30 July	68	18 Oct.
7	31 May	38	31 July	69	18 Oct.
8	1 June	39	1 Aug.	70	19 Oct.
9	5 June	40	2 Aug.	71	20 Oct.
10	6 June	41	3 Aug.	72	20 Oct.
11	7 June	42	4 Aug.	73	22 Oct.
12	8 June	43	6 Aug.	74	22 Oct.
13	11 June	44	6 Sept.	75	23 Oct.
14	13 June	45	7 Sept.	76	23 Oct.
15	14 June	46	8 Sept.	77	24 Oct.
16	15 June	47	11 Sept.	78	24 Oct.
17	18 June	48	12 Sept.	79	25 Oct.
18	19 June	49	13 Sept.	80	25 Oct.
19	20 June	50	14 Sept.	81	26 Oct.
20	21 June	51	15 Sept.	82	26 Oct.
21	22 June	52	17 Sept.	83	27 Oct.
22	25 June	53	18 Sept.	84	29 Oct.
23	26 June	54	19 Sept.	85	30 Oct.
24	27 June	55	20 Sept.	86	31 Oct.
25	28 June	56	24 Sept.	87	1 Nov.
26	17 July	57	1 Oct.	88	2 Nov.
27	18 July	58	4 Oct.	89	7 Nov.
28	19 July	59	5 Oct.	90	10 Nov.
29	20 July	60	6 Oct.	91	12 Nov.
30	21 July	61	9 Oct.	92	13 Nov.
31	23 July	62	10 Oct.	93	16 Nov.
				94	17 Nov.

cruises were intended primarily to test for suspended sediment. The St. Marys project was during cruises 52 to 56. Two days were spent sampling at stations along a traverse between Mackinaw City and De Tour, Mich. Cruises 53 to 55 were in the passages into Georgian Bay and in the adjacent portion of Lake Huron (map inset, Figure 1). Shipboard and laboratory determinations made during each chemical cruise are summarized in Table 3.

The ship was navigated and stations were established by using a gyro compass, radar, a sextant, and visual fixes. Water sample depths were determined by a Raytheon Precision Survey Fathometer, Model DE-723B, with a range of 0 to 250 in feet or fathoms and the depth presented as a graphic record on a calibrated paper chart.

Water samples were collected in 5-liter Niskin bottles at multiple levels at each station. The samples from stations located in shallow water were taken at the surface, mid-depth, and near bottom. Samples from stations located in deep water were taken at the surface and spaced at intervals ranging from 10 to 20 meters, with the deepest sample near the bottom. Bottom sediment samples were taken with a Shipek Sampler.

Water temperatures were recorded at sampling depth to the nearest hundredth degree Celsius by protected reversing thermometers ($\pm 0.02^\circ$ accuracy) attached to each Niskin bottle. The temperature of the water circulating through the sea chest, approximately 1.5 m below the surface, was recorded to the nearest tenth degree Celsius and printed with the meteorological data at 6-min intervals. Temperature profiles were recorded at each station with a Guildline Electronic Bathythermograph, Model 1800. The bathythermograph profiles were corrected by adding or subtracting the average difference between the reversing thermometer and bathythermograph temperature.

Transparency profiles were made with a G.M. Mfg. and Instrument Corp. Deep-Water Turbidity Meter, Model 17-M-11, modified by the U.S. Lake Survey. Color filters were not used. Transparency was determined by relating light transmission along a 1-m path through the water to the transmission along the same path through air, expressed as a percent.

Total suspended materials were determined in the field with 0.45-micron millipore filters and filtering 1000 ml samples during cruises 4, 5, 12, 16, 21, 22, 25, 29, 32, 35, 42, and 43. A 500-ml sample was filtered during cruises 46, 50, 57, 58, 65, 84, 90, and 93. Samples of approximately 475 ml were filtered through Whatman-40 filters for all other cruises.

Meteorological observations were recorded automatically at 0.1-hr intervals by a digital system employing solid state data gathering modules. Wind and wave observations were made while on station. The wave direction was not reported at all stations and in such cases the wind direction was used. Wave height observations are estimates. The period is based on an average time of 10 successive waves.

Table 3. Shipboard and Laboratory Measurements in Connection with Limnological Studies

Shipboard Measurements

Meteorological data (Printout each 6 min)

Wind speed (m/sec) (3 and 10 m above water)
 Wind direction (3 and 10 m above water)
 Barometric pressure (millibars) (3 m above water)
 Air temperature (°C) (3 and 10 m above water)
 Water temperature (1.5 m below water surface)
 Solar radiation (incident) (gram-calories per sq. cm) (10 m above water)
 Solar radiation (refl. and incident) (3 m above water)
 Relative humidity (3 m above water)
 Dew point

On Station

Water

Water temperature (°C)
 Reversing thermometers at sample depth
 Electronic bathythermograph
 Air-water interface temperatures
 Transparency (relative to 100% in air)
 Secchi disc (m)
 pH
 Eh (volts)
 Total and phenolphthalein alkalinity (mg/l CaCO₃)
 Specific conductance (micromhos at 25°C)
 Dissolved oxygen (mg/l and pct. sat.)
 Coliform bacteria (membrane filter proc.)

Waves

Height (m)
 Period (sec)
 Direction (nearest 10°)

Bottom Sediment

Description (physical)
 pH
 Eh

Chemistry Laboratory

Dissolved ions

Nitrate¹ (Brucine method, A.P.H.A.², 1965)
 Phosphate¹ (Ammonium molybdate method, U.S.G.S.³, 1965)
 Sulfate¹ (Turbidimetric method, A.P.H.A.², 1965)
 Silica⁴ (Molybdate Blue method, U.S.G.S.³, 1960)
 Magnesium⁴ (Atomic Absorption tech., P.E.⁵, 1971)
 Calcium⁴ (Atomic Absorption tech., P.E.⁵, 1971)
 Sodium⁴ (Atomic Absorption tech., P.E.⁵, 1971)
 Potassium⁴ (Atomic Absorption tech., P.E.⁵, 1971)
 Chloride (AgNO₃ titration)

COD

Organic carbon
 Suspended sediment (mg/l)

Bottom sediment

Percent solids
 Percent volatiles
 Oil and grease
 COD

¹Beckman DU-2 Spectrophotometer.

²American Public Health Association.

³U.S. Geological Survey.

⁴Perkin-Elmer Atomic Absorption Spectrophotometer.

⁵Perkin-Elmer Corporation.

2.2 Chemical Analyses

The methods used in the water analysis are those described in Standard Methods (American Public Health Association, 1965), Rainwater and Thatcher (1960), Fishman and Skougstad (1965), and Perkin-Elmer Corporation (1971).

Water samples were analyzed immediately in the *Shenehon* laboratory for dissolved oxygen, specific conductance, phenolphthalein and total alkalinity, pH, Eh (oxidation-reduction potential), the pH and Eh of the interstitial water of the bottom sediment, and total coliforms.

Dissolved oxygen values were determined with a Beckman Dissolved Oxygen Analyzer, Model 777. After two separate tests were made on each sample, the highest partial pressure and the lowest sample temperature readings were used for calculating the dissolved oxygen. The *in situ* temperature was that recorded by the reversing thermometer at the sampling depth.

Specific conductance was measured with an Industrial Instruments Conductivity Bridge Model RC-19. Two separate tests were made on each sample and the average expressed in micromhos at 25°C.

Chloride concentrations were determined by the argentometric method and titration of a 50-ml sample of lake water. The silver nitrate was standardized and the reagent blank value determined at the beginning of each day.

Phenolphthalein and total alkalinity values were determined by titrating 100-ml water samples with standard acid (H_2SO_4) to the end-points of pH 8.2 and 4.5, respectively. The end-points were determined with the pH meter and the results expressed in milligrams per liter of calcium carbonate.

Measurements of pH and Eh were made with a Beckman Digital pH meter, a glass pH electrode, calomel fiber junction reference electrode, and a platinum Eh electrode. As a means of avoiding contamination, the electrodes were rinsed in a sample of the lake water to be tested. Between tests the electrodes were immersed in distilled water. Tests of the interstitial water of the bottom sediment were made by inserting the electrodes into the soft sample.

Water samples in 500 ml plastic bottles were preserved with chloroform and stored in a dark area below deck to be analyzed later. These samples were transferred at the end of each cruise or survey period to the Great Lakes Research Center laboratory in Detroit, Mich. A Beckman DU-2 Spectrophotometer with flame attachment was used to analyze nitrate, phosphate, sulfate, and silica, and a Perkin-Elmer Atomic Absorption Spectrophotometer was used for calcium, magnesium, sodium, and potassium. Standard curves were constructed for each test and cruise. Tests for

nitrate and phosphate were made on unfiltered samples upon arrival at the laboratory. Sample anion concentrations were determined by computer application of the absorbancy values to a standard curve adjusted by paired test standards run after each set of 10 to 20 samples in order to compensate for any change or drift in the spectrophotometer response. The cation concentrations were also adjusted by paired test standards and read directly from a recorder strip chart.

The bottom sediment was dried overnight at 100-105°C and the weight expressed as a percentage of the wet weight. Volatiles were determined by burning at 600°C for 1 hr and were reported as a percentage of the dry solids. The concentration of hexane extractable hydrocarbons was determined by distillation and the weight reported as a percentage of the dry solids. The chemical oxygen demand was determined by refluxing samples of the bottom material.

3. PRECISION LIMITS

The degrees of precision shown in Table 4 were determined for nitrate, phosphate, sulfate, and silica by a computer comparison of pairs of test standards to the standard curve used to determine the sample concentration. A pair of test standards was run after each set of 10 samples for nitrate and after each set of 20 samples for phosphate, sulfate, and silica. Calcium, magnesium, sodium, and potassium analyses were run in sets of 10 samples, followed by one standard and at least one additional standard bracketing the concentration range after each 20 samples. For both chloride and alkalinity the estimated precision is based on the change in concentration produced by one drop (0.05 ml) of titrant and the assumption that the end-point was within ± 1 drop. Two readings were made on each sample for specific conductance and deviations from the mean of each pair were used to compute the average deviation. Of the 100 sample pairs randomly selected, 83 percent were within 2 micromhos of the mean. The estimated precision of the dissolved oxygen determination is based on the assumption that the partial pressure is accurate to 1-mm of mercury. The average difference between the two partial pressure readings for each sample was less than 1-mm of mercury.

Tests for nitrate and phosphate were made on unfiltered samples. From the end of a cruise to the date of analysis, there was an interval ranging from 0 to 35 days for phosphate and from 2 to 23 days for nitrate. These samples were preserved (CHCl_3) to fix the nitrogen and phosphorus, but were not refrigerated.

4. DATA PRESENTATION

The limnological data are summarized by cruise for each sampling depth at a given station (Appendix A). Nitrogen concentrations were

Table 4. Measurement Precision

Variable	Units	Estimated precision	Average deviation*
Nitrate-N**	mg/l		±0.004
Phosphate-P**	mg/l		±0.0003
Sulfate	mg/l		±0.03
Silica	mg/l		±0.01
Calcium	mg/l	±0.5	
Magnesium	mg/l	±0.1	
Sodium	mg/l	±1.0	
Potassium	mg/l	±0.1	
Chloride	mg/l	±0.5	
Specific conductance	micromhos at 25°C		±1.0
Total alkalinity	mg/l CaCO ₃	±0.5	
Dissolved oxygen	mg/l	±0.1	
Dissolved oxygen	Percent sat.	±1.0	

*Average of the deviations of the test standards from the standard curve.

**Analysis of unfiltered samples that were CHCl₃ poisoned and stored for variable lengths of time.

calculated from nitrate by multiplying by a factor of 0.226. Phosphorus concentrations were calculated from phosphate by multiplying by a factor of 0.326.

The wind, wave, and bottom sediment data, with the exception of pH and Eh, are summarized by cruise and station (Appendix B).

In the statistical summary, lake-wide means, standard deviations, and sample sizes are presented by depth and cruise period for selected variables (Appendix C).

5. ACKNOWLEDGMENTS

The program was formulated and directed by A. P. Pinsak. Ship services were provided by the Facilities Division, U.S. Lake Survey Center. *Shenelon* operations were under the direction of R. E. Ruh.

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